

# METHOD OF ESTABLISHING INTER BASE-STATION SYNCHRONIZATION AND MOBILE RADIO COMMUNICATION SYSTEM USING THE METHOD

## CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of U.S. patent application Ser. No. 08/132,247 filed on Oct. 6, 1993, the contents of which are incorporated herein by reference.

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a method of establishing synchronization among a plurality of radio base stations forming a mobile radio communication system operated in a time division multiple access (TDMA) mode, a code division multiple access (CDMA) mode or the like and a mobile radio communication system using this method.

### 2. Description of the Related Art

In a mobile radio communication system, effective utilization of frequencies is achieved by adopting a cellular system in which the same frequency is allocated to a plurality of radio communication stations covering remotest cells. Further, various types of systems for narrow-band transmission using signal compression and modulation-demodulation techniques are being studied, and utilization of a half rate of an audio codec is also studied in a digital system.

In such a situation, as a countermeasure to an increase of traffic, it is proposed in a mobile radio communication system, in particular in a mobile telephone system for automobiles, to gradually reduce service zones of respective radio base stations forming conventional large or medium zones, e.g., to zones each having a radius of 5 Km to 3 Km. The effective utilization of frequencies by forming smaller zones is useful especially in a personal radio communication system which is planned to be put into practical use. In this personal radio communication system, a small zone system is studied in which each zone has an area of several hundred meters to several ten meters in the radius which is called a microcell or a picocell, as disclosed in the Transactions of the Institute of Electronics and Information Communication Engineers in Japan (B), J71-B, No. 5, May 1988 pp. 633-639.

In such a small zone system, the number of radio base stations becomes very large sometimes. Thus, it is planned to install these radio base stations on utility poles, building walls or the like. In this case, it is necessary to make the radio base station much more compact in size and lighter in weight, as well as to reduce the cost thereof. In such a small zone system, especially under free sale circumstances of the terminals (mobile stations) including radio base stations, many radio base stations will be increased successively in order to cope with high traffic. This will result in the following problems.

Namely, when many radio base stations are installed successively, it is expected to form what is called a multizone where zones of adjacent radio base stations overlap with each other so that the radiowave transmitted from a radio base station can be received directly by another adjacent radio base station. In such a multizone, probability of loss in telephone communication is increased with the increase of interference by an adjacent radio base station,

and calling becomes impossible at the worst. When a TDMA system is adopted in such a multizone, it is required to establish synchronization between frames used by respective radio base stations provided in contiguous zones forming a multizone, in order to assure functions of detecting and/or avoiding interference, that is, to cause the radio base station in each zone to perform telephone communication with a mobile station located in that zone at the same frame timing as that at which the adjacent base station performs its telephone communication, as disclosed, for example, in "Autonomous Decentralized Inter-Base-Station Synchronization for TDMA Microcellular Systems" Akaiwa et al IEEE 1991 pp. 257-262. As to the necessity of synchronization between radio base stations, it has been reported that the efficiency in using the slots is lowered by 25% to 30% in an asynchronous condition as compared with that in a synchronous condition. Namely, this is because, when such an interference is generated in one zone, it happens sometimes that an unused vacant channel is mistaken as an used channel by noises due to the interference caused by drift of the frame timing, thus preventing the vacant channel from being used.

When it is intended to realize synchronization between the adjacent radio base stations based on the control from a higher rank exchange like a telephone system for automobiles, the following problems are caused. Firstly, many control signal lines are required for connecting each of the radio base stations with the exchange, thus causing a rise of the cost of equipment. Secondly, a large-sized computer coping with a large load for synchronization is necessary in the exchange side, and hardware for establishing synchronization is also necessary in the side of each radio base station, thus also causing a rise of the cost of equipment. Thirdly, in the case of a personal handy phone "PHP" system, the following problems are caused.

Namely, the PHP is applied to indoor mobile terminals in offices or homes and outdoor mobile terminals for public telephone communication. In offices, a business cordless telephone system called a behind PBX is introduced and the synchronization among respective radio base stations is established based on a command from the PBX. In this case, it is necessary to make the control signal common to the business cordless telephone system and the PHP system for synchronization between the radio base stations thereof and hence complicated processing is required every time a new radio base station is installed.

Further, since a plurality of communication enterprises use switching systems having different specifications sometimes in railway stations, airports or the like, complicated adjustment work requiring time and labor is necessary to unify specifications relating to synchronization control among respective switching systems.

It is desired to provide a method of establishing inter-base-station synchronization capable of performing processing of establishment of inter-base-station synchronization only by autonomous control of respective radio base stations without depending on the control by a higher rank station, thereby to reduce a burden of the higher rank station and a mobile radio communication system using this method.

## SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method of establishing inter-base-station synchronization in a mobile radio communication system having a plurality of base stations forming a multizone, by autonomous-control of respective base stations without relying on the control by